Australian Government
Department of Defence
Defence Science and
Technology Organisation

# Calm Water Resistance of a 1:25 Scale Model of the Armidale Class Patrol Boat

*Terry Turner*[1] *and John McKillop*[2]

**[1]Maritime Platforms Division**
**Defence Science and Technology Organisation**

**[2]Directorate of Naval Platform Systems**
**Navy Engineering Division**

DSTO-TR-2768

**ABSTRACT**

DSTO has recently joined the International collaborative consortium FAST3.JIP with the aim to develop a numerical capability for the prediction and analysis of the resistance, seakeeping and seaway loads of high speed semi-planing hullforms. As part of this research program DSTO, in collaboration with DNPS, have undertaken a series of calm water resistance scaled model tests on the Armidale Class Patrol Boat, (ACPB). The data obtained from this model test program will be utilised to validate the numerical tools within the FAST3.JIP. Once fully validated these tools can be utilised to increase the understanding of any potential fuel saving strategies for the ACPB's and the through life structural management of the platform. The results will also be utilised to provide stern flap position advice to the Royal Australian Navy for minimisation of fuel consumption at various displacements and ship speeds. This report presents the data from the experimental test series.

*Published by*

*Maritime Platforms Division*
*DSTO Defence Science and Technology Organisation*
*506 Lorimer St*
*Fishermans Bend, Victoria 3207 Australia*

*Telephone: (03) 9626 7000*
*Fax: (03) 9626 7999*


*AR 015-447*
*November 2012*

**APPROVED FOR PUBLIC RELEASE**

# Calm Water Resistance of a 1:25 Scale Model of the Armidale Class Patrol Boat

## Executive Summary


The Armidale Class Patrol Boats, ACPBs, are a semi-planing hullform which has significant differences in the resistance, manoeuvring and seakeeping capabilities when compared to other RAN platforms. The Australian Defence Science and Technology Organisation, DSTO, has recently joined the International Collaboration, FAST3 Joint Industry Program, which is aimed at developing more advanced numerical tools to accurately predict the non linear motions, resistance, manoeuvring and wave induced loads of these semi-planing hull forms.

As part of the development of these numerical tools an extensive validation study is required. DSTO, in collaboration with the Directorate of Naval Platform Systems, DNPS, has recently undertaken a series of calm water resistance tests on a scaled model of the ACPB to obtain a database set for these validation studies. This experimental program included studying the effect that speed, displacement and the angle of the stern flaps had on the resistance of the hull. Three trim tab settings were studied: (1) retracted by 6.4 degree from the neutral, (2) tab parallel to the baseline along the neutral line and (3) the trim tab extended by 6.4 degree from the neutral.

Outcomes from this study showed that, for all load conditions tested, when the speed of the vessel was less than 15 knots, the lowest resistance was recorded when the trim tab was in the retracted position. For speeds greater than 15 knots, an extended trim tab resulted in the lowest resistance.

It was observed that the dynamic trim of the vessel was influenced by the angle at which the trim tab was set. When the trim tab was in the retracted position, the ACPB always had a stern down trim across the entire speed range tested. When the trim tab was set in the neutral position, the ACPB had a bow down trim for speeds less than 15 knots and a stern down trim for speeds greater than 15 knots. When the trim tab was extended, the speed at which the ACPB changed from a bow down trim to a stern down trim increased to between 17.5 and 20 knots.

For all load conditions and speeds tested, the rise of the vessel increased as the angle of the trim changed from retracted to extended.

For speeds greater than 15 knots, the effective power was higher when the trim tabs were set in the retracted position when compared to the neutral position which in turn was higher than for the extended setting. For speeds lower than 15 knots there is very

little difference in the effective power for all the trim tab settings studied. Throughout this lower speed range the trim tabs could be operated in the fully retracted position as there is no benefit in terms of effective power when operating with them extended.

The data from this study will now be used as a validation dataset for the numerical tools being developed within the FAST3 Joint Industry Program. Once fully validated, these tools will provide the Australian Department of Defence with a capability to enhance their understanding of the operational performance of these semi-planing platforms. This is important for the ACPB's through life management, including fuel saving studies and the life of type structural fatigue studies. These tools are also applicable to support any future acquisition programs that may utilise semi-planing craft

# Authors

**Terry Turner**
Maritime Platforms Division

*Terry Turner currently works in the Naval Architecture and Platform Systems Analysis group within MPD. He is currently involved in several research programs relating to seakeeping, resistance and seaway loads of naval vessels. From May 2007 until May 2008 he was awarded a Defence Science Fellowship where he was attached to the Maritime Research Institute Netherlands. He is the Australian point of contact for several international research collaborations in the areas of ship motions, stability and seaway loads..*

---

**John McKillop**
Directorate of Navy Platform Systems

*John McKillop currently works in the Concepts and Liaison group within DNPS. He is currently involved in various activities and studies relating to resistance & propulsion, seakeeping and concept design.*

---

*This page is intentionally blank*

# Contents

# Acronyms

| | |
|---|---|
| ACPB | Armidale Class Patrol Boat |
| AMC | Australian Maritime College |
| AP | Aft Perpendicular |
| $C_T$ | Total Resistance Coefficient |
| DNPS | Directorate of Navy Platform Systems |
| DSTO | Defence Science and Technology Organisation |
| FP | Forward Perpendicular |
| Fr | Froude Number |
| ITTC | International Towing Tank Conference |
| LVDT | Linear Variable Displacement Transducer |
| LWL | Length Waterline (m) |
| MARIN | Maritime Research Institute Netherlands |
| MPD | Maritime Platforms Division |
| MS | Mid Ships |
| $P_E$ | Effective Power (kW) |
| $\rho$ | density of water ($kg/m^3$) |
| $R_T$ | Total Resistance (N) |
| $S$ | Wetted Surface Area ($m^2$) |
| $V$ | Speed (m/sec) |
| $V_k$ | Speed (knots) |

*This page is intentionally blank*

# 1. Introduction

The Australian Department of Defence is currently undertaking a Strategic Reform Program [1] across the whole of Defence with a focus on reducing costs by making changes to the way the Department undertakes business. One of the key areas of this reform is the ability to fully understand and manage the operating costs of military platforms. For naval platforms this can involve a range of activities including the through life structural management of the platform and any potential cost savings by reducing fuel consumption.

The Maritime Platforms Division, MPD, of the Defence Science and Technology Organisation are members of the international FAST3 Joint Industry Program, in which a research program to develop the tools and techniques to enable an increased understanding of the fatigue life of aluminium naval platforms is underway. This program of work is primarily focussed on the Armidale Class Patrol Boats, ACPBs. One of the components of this study is to determine the appropriate wave loading, including slamming, on the vessel in a variety of operational environments and for a range of operational speeds so that a fatigue life assessment can be undertaken. This loading can be determined either from ongoing full scale monitoring or using advanced non linear numerical tools.

Traditional seakeeping, manoeuvring, resistance and operational load numerical prediction tools are based on the assumption that the hullform being considered is a displacement hullform. Maritime vessels can be defined into three categories based upon a speed/length ratio:

$$\text{Speed/length Ratio} = V_k / (\sqrt{LWL})$$

Where

$V_k$ = speed in knots
LWL = length waterline

These categories are: (1) displacement, (2) semi-planing and (3) planing hullforms. A displacement hullform is one which the hull is predominantly supported by buoyancy and changes in draft and trim are small with increasing speed. These hullforms typically have a speed/length ratio up to 1.3. A semi-planing hullform is capable of developing a moderate amount of lift and start to trim down by the stern with increasing speed. The semi-planing hullforms typically have a speed/length ratio between 1.3 and 3.0. A planing hullform is configured to develop dynamic lift so that the draft decreases with speed and these typically have a speed/length ratio greater than 3.0 [2].

The ACPB operates across both the displacement and semi-planing hullform modes and even slightly into the planing mode. When operating at slower speeds, i.e. less than 9-10 knots the ACPB is considered to be in displacement mode. At higher speeds, between approximately 10-22 knots, the ACPB is considered to be in semi-planing mode. As previously stated the applicability of seakeeping tools when analysing the ACPB's is limited to the slower speed range i.e. when the vessel is operating in displacement mode. For any understanding of the

capability of these hullforms over the entire operational speed range, advanced non linear numerical tools are required to be able to analyse the hullform in the semi-planing mode.

When the ACPBs are operating in the semi-planing mode the trim of the vessels varies with speed therefore prior to any seakeeping analysis for the prediction of seaway and slamming loads, it is important that validation studies of the prediction of the running trim angles with speed is undertaken. A 1:25 scale model of the ACPB was constructed and a series of calm water resistance tests were undertaken in the Towing Tank at The Australian Maritime College, University of Tasmania. The objective of this model test program was to generate a calm water resistance and running trim versus speed relationships for the ACPB at several different operational load conditions and a range of trim tab angles. The data obtained from this model test series will be used to validate the numerical tools being developed within the FAST3.JIP.

Another objective of the calm water resistance test program is to support the research program that MPD is currently undertaking into the effects that biofouling of the hull have on the performance and fuel consumption of the ACPBs [3]. This work complements the Directorate of Navy Platform Systems, (DNPS) study into the effect that stern trim tab angles have on the resistance of the ACPB. An increase in biofouling and hence resistance of the vessel leads to an increase in fuel consumption. Also if the angle of the trim tabs can be optimised to minimise the resistance of the patrol boats, then significant savings in fuel consumption could be achieved.

The knowledge gained and the capabilities developed in both these research programs will greatly enhance the understanding of the operational performance of the ACPB's and any life of type extension studies. Outcomes will also support the Strategic Reform program in providing guidance to the Royal Australian Navy for any potential cost saving strategies for fuel consumption. These capabilities and the increased knowledge in these areas will also be valuable when considering any potential candidates for future acquisition programs that may utilise a semi-planing craft.

This report will provide an overview of the approach undertaken in the experimental program and the results obtained. Validation studies using this data and interpretation of these results will be the subject of subsequent reports.

# 2. Experimental Design

## 2.1 Coordinate System

The right-handed Cartesian coordinate system is used to describe the model in three-dimensional space. The direction of the principal axes of this system is defined in Table 1. The model reference datum is located longitudinally at Station 0 (transom), transversely on the centreline and vertically on the baseline.

*Table 1 Coordinate System*

| Axis | Direction |
|---|---|
| X | Positive Forward |
| Y | Positive Starboard |
| Z | Positive Down |

## 2.2 Armidale Class Patrol Boat Model

### 2.2.1 1:25 scale Armidale Class Patrol Boat Model Description

A 1:25 scaled model of the Armidale Class Patrol Boat was constructed of fibreglass and was designed so that appendages were removable to allow for both calm water resistance testing of the bare hull and seakeeping tests of the appended hullform. The scale model also included a permanently attached spray rail along the forward section of the bow. Figure 1 shows a photograph of the appended hull. The station and waterline markings shown on the hull are labelled according to ITTC recommended procedures [4]. This procedure uses a 10 section numbering system starting from aft with station 0 at the Aft Perpendicular (intersection of design waterline and stem).


*Figure 1 Photograph of 1:25 Scale model of Armidale Class Patrol Boat*

The removable appendages included a pair of bilge keels, roll stabiliser fins, the skeg and a set of rudders. The model also included a pair of adjustable trim tabs at the stern. The hullform and associated appendages were all scaled and manufactured according to the AUSTAL Ships drawings for the 56.8m Armidale Class Patrol Boat [5-11].

### 2.2.2 Hull Surface Finish

The model hull surface was finished with 600 grade wet and dry sandpaper.

### 2.2.3 1:25 scale Armidale Class Patrol Boat Model Particulars.

Table 2 shows the model particulars at the design loading condition.

*Table 2 Armidale Class Patrol Boat 1:25 Scale Model Design Load Particulars*

| **Particular** | **Full Scale ACPB [12]** | **1:25 Scale ACPB Model** | **Unit** |
|---|---|---|---|
| Model Identification Number | - | AMC 12-05 | - |
| Length Overall | 55.920 | 2.237 | m |
| Length between Perpendiculars | 52.165 | 2.087 | m |
| Length on Waterline | 52.165 | 2.087 | m |
| Breadth on Waterline | 7.592 | 0.304 | m |
| Breadth Overall | 9.667 | 0.387 | m |
| Design Draft | 2.25 | 0.090 | m |
| Displacement at Design Draft | 336.3 (t) | 21.523 | kg |

### 2.2.4 Mounting Arrangement

The ACPB model was fitted with two mounting pads to enable it to be connected to Towing Tank carriage at The Australian Maritime College. The mounting pad design and location are in accordance with the AMC construction guidelines [13]. These guidelines are based on ITTC recommended procedures. The arrangement of the pads was such that the model was towed horizontally through the intersection of the thrust line and station 7.5 of the model. As this is not along the extension of the propulsion thrust line, 3 test runs were undertaken (Runs 25-27) at the higher speeds by applying a trim correction moment. This was to determine if the mounting arrangement had an effect on the resistance and running trim. No appreciable difference in the results was recorded so the speed dependent trim correction moment was disregarded for the remainder of the test program. The physical arrangement of the mounting pads within the models is illustrated in Figure 2. The type, size and location of the models' mounting pads are detailed in Table 3.

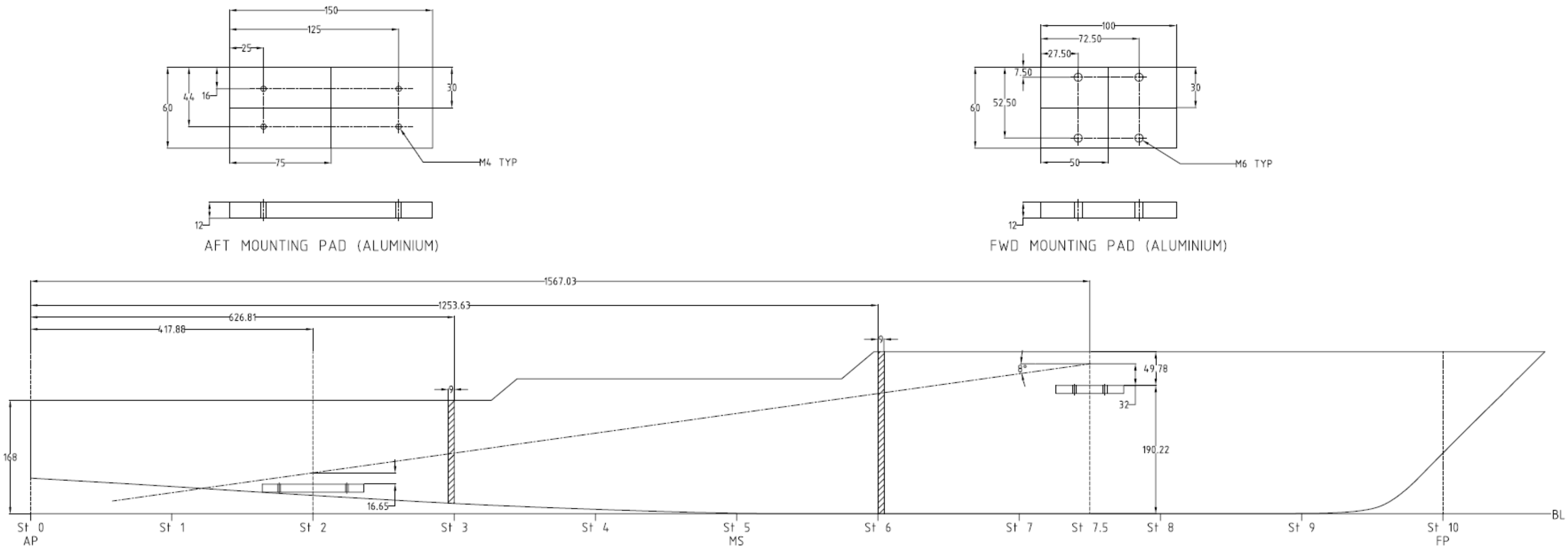


*Figure 2 Profile View of mounting pad arrangement within ACPB model*

*Table 3 Towing Tank Mounting Pad Descriptions and Dimensions*

| **Particular** | **AMC 12-05** | **Unit** |
|---|---|---|
| **Forward Pad** | | |
| Connection Type | Ball Joint No. 7 | - |
| Pad Material | Aluminium | - |
| Pad Size (length x width x thickness) | 100 x 60 x 12 | mm |
| Longitudinal hole separation (centre to centre) | 45 | mm |
| Transverse hole separation ( centre to centre) | 45 | mm |
| Hole thread size | M6 | - |
| Longitudinal location of pad centre (fwd of AP) | 1567 | mm |
| Transverse location of pad centre (off centreline) | 0 | mm |
| Vertical location of pad centre (above baseline) | 190 | mm |
| | | |
| **Aft Pad** | | |
| Connection Type | Aft Slide No. 5 | - |
| Pad Material | Aluminium | - |
| Pad Size (length x width x thickness) | 100 x 60 x 12 | mm |
| Longitudinal hole separation (centre to centre) | 65 | mm |
| Transverse hole separation ( centre to centre) | 25 | mm |
| Hole thread size | M4 | - |
| Longitudinal location of pad centre (fwd of AP) | 418 | mm |
| Transverse location of pad centre (off centreline) | 0 | mm |
| Vertical location of pad centre (above baseline) | 59 | mm |

As the aft towing post is connected to the model via a sliding arrangement with minimal longitudinal restraint, the towing force exerted on the model is assumed to act completely through the forward towing post and act horizontally through the tow ball.

### 2.2.5 Boundary Layer Turbulence Stimulation Device

Turbulence stimulators were fitted to the model for the purpose of transitioning the boundary layers during resistance experiments. The turbulence stimulators used were in accordance with the guidelines prescribed by AMC [13] .

A series of cylindrical metal studs were used as the turbulence stimulators which were fixed to the model in a span-wise array. The dimensions of the transition studs are included in Table 4. The studs were located along the sides of the hull at hull marking station 9 as shown in Figure 3.

*Table 4 Turbulence Stimulation Device: Dimensions*

| Parameter | Dimension | Unit |
|---|---|---|
| Stud Plan-form Diameter (d) | 3.0 mm | mm |
| Stud Profile Height (k) | 3.0 mm | mm |
| Stud Span-wise Spacing | 20.0 mm | mm |
| Number of Studs | 10 on each side | - |

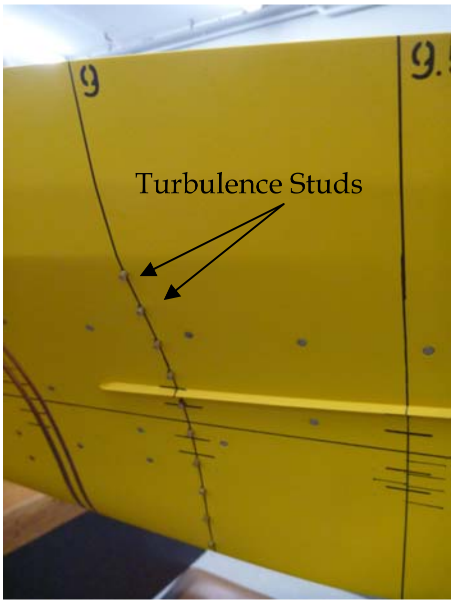


*Figure 3 Photograph showing Turbulence Stimulation Studs*

### 2.2.6 Additional Instrumentation

#### *2.2.6.1 Force Transducer*

A MARIN (Maritime Research Institute Netherlands) one component force transducer, Type 421 No. 6, was used to record the resistance (drag force) of the model for the various tests undertaken.

#### *2.2.6.2 Linear Variable Displacement Transducer*

The vertical displacement of the model was recorded using two linear variable displacement transducers, (LVDT): one located on the forward post and one on the aft post of the towing carriage.

#### *2.2.6.3 Pressure Gauges*

An array of 20 piezoresistive pressure gauge mounts was integrated into the forward section of the bow region for the recording of the slamming pressures during seakeeping

experiments. During the calm water resistance testing these mounts were plugged flush with the hull surface.

*2.2.6.4 Wave Probes*

Two thin copper strip wave probes were mounted on the hull surface at 1.64 m and 1.78 m forward of the aft perpendicular. These wave probes will be used during the seakeeping experiments to determine the wave phase angle relative to the model. These wave probes were not utilised during the calm water resistance testing.

### 2.2.7 Air Resistance on Model

Air resistance can be an important area to address when testing marine vehicles and can have an effect on the determination of the overall resistance of the model being tested. In order to minimise this effect a perforated screen measuring 770 x 505 mm was positioned forward of the model. The longest edge of the screen was orientated horizontally and positioned approximately 30 mm above the water surface. Thus, the coefficient of air resistance $C_{AA}$ is assumed to be zero [13].

## 2.3 Experimental Test Program

### 2.3.1 Test Matrix

A total of 145 individual test runs were undertaken over a range of speeds, displacements, static trims and trim tab settings. A copy of the full test matrix is shown in Appendix A.

### 2.3.2 Load Conditions Tested

Table 5 outlines the relevant hydrostatics for the load conditions tested in the calm water resistance testing program. Both the model scale, (model), and full scale, (ship), values are shown. The model scale hydrostatics was calculated for fresh water whereas the full scale hydrostatic values are for salt water. All values are for the bare hull, i.e. no appendages attached except for Load Condition 1-(appended). When changing the model from Load Condition 1 to Load Condition 1-(appended), the various appendages were added to the model and the equivalent weight of these appendages was removed from the model to enable the same displacement to be maintained.

*Table 5 ACPB Hydrostatics for Load Conditions tested*

| **Load Condition** | **Displacement** | | **Trim** | | **LWL** | | **S** | |
|---|---|---|---|---|---|---|---|---|
| | model (kg) | ship (t) | model (m) | ship (m) | model (m) | ship (m) | model ($m^2$) | ship ($m^2$) |
| **1** | 18.732 | 300.5 | 0.000 | 0.000 | 2.085 | 52.13 | 0.590 | 368.9 |
| **2** | 18.732 | 300.5 | 0.012 | 0.300 | 2.078 | 51.95 | 0.584 | 365.1 |
| **3** | 18.732 | 300.5 | 0.024 | 0.600 | 2.071 | 51.77 | 0.579 | 361.9 |
| **4** | 21.229 | 340.6 | 0.000 | 0.000 | 2.090 | 52.25 | 0.625 | 390.9 |
| **5** | 14.985 | 240.4 | 0.000 | 0.000 | 2.077 | 51.93 | 0.531 | 331.8 |
| **1-(appended)** | 18.732 | 300.5 | 0.000 | 0.000 | 2.085 | 52.13 | 0.648 | 404.9 |

### 2.3.3 Speed Range Tested

The calm water resistance and dynamic rise and trim were measured across a range of forward speeds. The full scale speeds and respective Froude numbers for the test runs are listed in Table 6.

*Table 6 Speeds at which the model was tested.*

| Full Scale Speed (1:1) (knots) | Model Speed (m/s) | Froude Number (Fr) | Displacement Mode |
|---|---|---|---|
| 5 | 0.51 | 0.11 | displacement |
| 7.5 | 0.77 | 0.17 | |
| 10 | 1.03 | 0.23 | |
| 12.5 | 1.29 | 0.28 | semi-planing |
| 15 | 1.54 | 0.34 | |
| 17.5 | 1.80 | 0.40 | |
| 20 | 2.06 | 0.45 | |
| 22.5 | 2.31 | 0.51 | |
| 25 | 2.57 | 0.57 | planing |
| 27.5 | 2.83 | 0.62 | |
| 30 | 3.09 | 0.68 | |

### 2.3.4 Trim Tab Settings

The angle of the trim tabs was able to be adjusted and the effect of varying this angle on the resistance of the model was studied. The definitions of the angles of the trim tab setting for this test program are outlined in Table 7. These definitions are based on the neutral position as shown on AUSTAL Aft Trim Tab Detail Drawing [10]. The neutral position is defined as the position where the outboard underside corner of the flap is level with the lower edge of the transom at the trim tab recess; see "View on Frame 46 Looking Fwd" on AUSTAL Aft Trim Tab Detail Drawing [10]. The angle of 6.4 degree was used due to the limits that the trim tab on the scaled model could be set at. These angles are accurate to ± 0.1 degree. Figure 4 - Figure 6 shows photographs of the three different trim tab settings.

*Table 7 Trim Tab angle definitions.*

| Trim Tab Angle Definition |
|---|
| Tab retracted by 6.4 degree from neutral |
| Tab parallel to baseline along neutral line. |
| Tab extended by 6.4 degree from neutral |

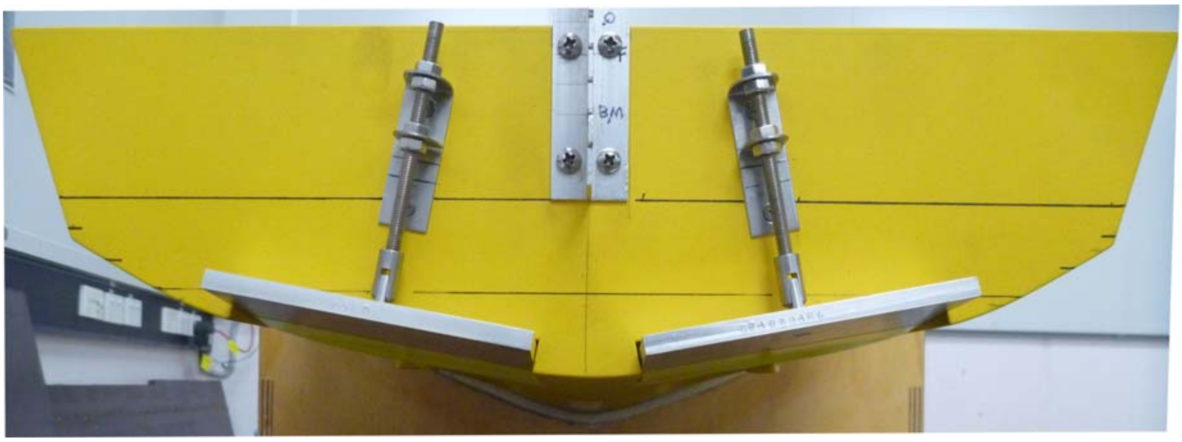

*Figure 4 Photograph of Trim Tab in 6.4 degree retracted position*

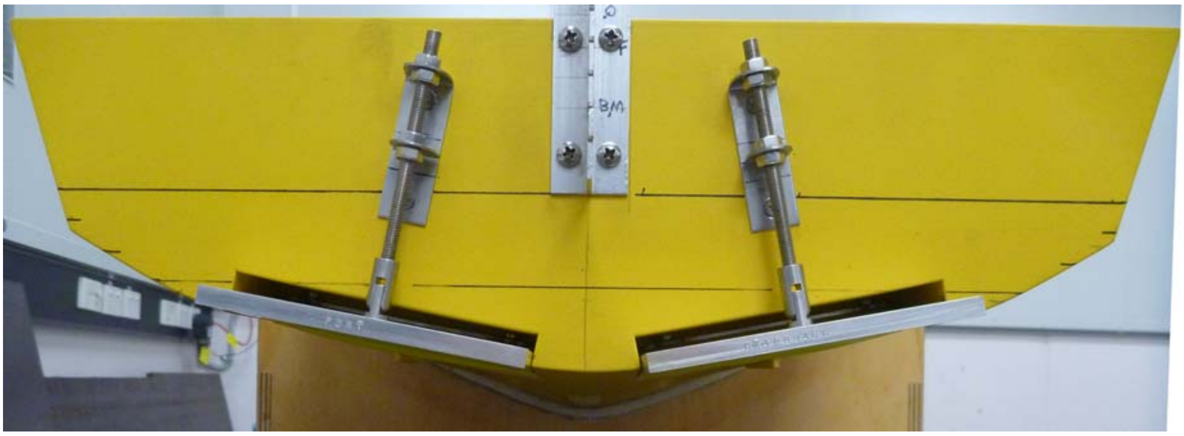

*Figure 5 Photograph of Trim Tab in neutral position*

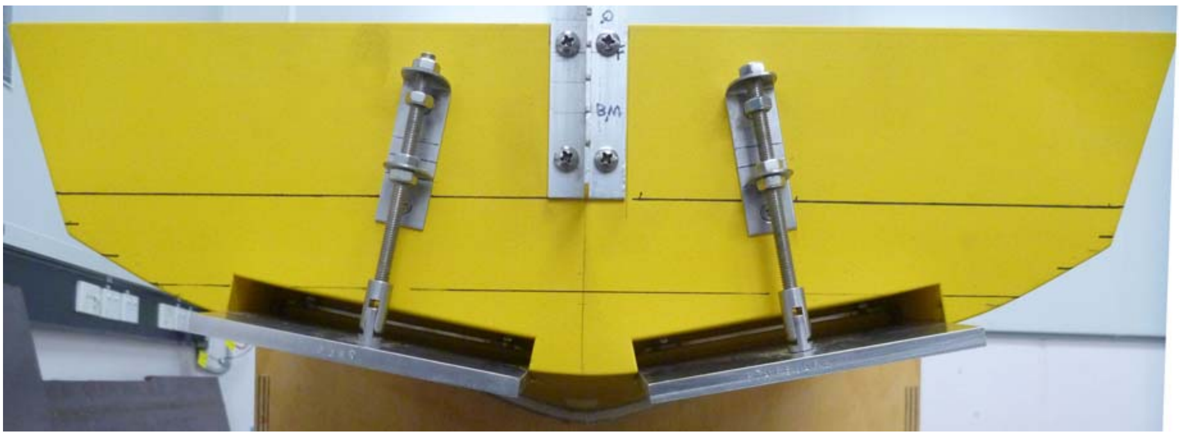

*Figure 6 Photograph of Trim Tab in 6.4 degree extended position*

A strip of tape as placed over the gap at the forward end of the trim tab recess in the hull, as this was more exposed at model scale than on the full scale ACPB. Taping over this recess was

deemed to be a close approximation to the full scale trim tab recess arrangement. All subsequent runs were conducted with the tape attached.

## 2.4 Data Processing

### 2.4.1 ITTC 1978 Method.

The calculation of the total resistance coefficient was achieved by using the procedure as outlined in the ITTC recommended procedures [14].

The total resistance coefficient was calculated using:

$$C_T = \frac{R_T}{0.5 \rho S V^2}$$

Where:
$C_T$ = total resistance coefficient
$R_T$ = total resistance (N)
$\rho$ = density of water (kg/m$^3$)
$S$ = wetted surface area (m$^2$)
$V$ = speed (m/s)

The effective power was calculated using:

$$P_E = C_T 0.5 \rho S V^3$$

Where:
$P_E$ = Effective Power (kW)
$C_T$ = total resistance coefficient
$\rho$ = density of water (kg/m$^3$)
$S$ = wetted surface area (m$^2$)
$V$ = speed (m/s)

### 2.4.2 Wetted Surface Areas

Wetted surface areas for the static condition were adopted in the resistance and effective power calculations. Wetted surface area is used in the calculation of the total resistance coefficient for the model and the effective power calculation at ship scale. Although the wetted surface area varies with speed the accepted ITTC procedure for determining the resistance and power uses static wetted surface area.

# 3. Results and Discussion

The ACPB model was tested over a range of speeds, displacements, static trims and trim tab settings. The effect that these variables had on the total resistance coefficient, running trim (static + dynamic trim), rise at the centre of gravity and effective power of the vessel was determined and plotted at full scale. These plots are shown and discussed in the following sections. Some experimental runs were repeated as a check on the reproducibility of the data recorded. These repeated runs are also shown in the plots. All dimensional values eg speed, trim etc., discussed in the following section relate to full scale values.

## 3.1 Load Condition 1: (300.5 t displacement, 0.0 m static trim)

Figure 7 shows the ship scale Total Resistance Coefficient versus Froude Number for the 300.5 t displacement, 0.0 m static trim condition. For this load condition, it is shown that for speeds less than a Froude number equal to 0.34 (15 knots), the lowest resistance was recorded when the trim tab was retracted by 6.4 degrees from the neutral position. As the trim tab angle was extended the resistance increased.

For speeds above 15 knots, a trend in the resistance curve in the opposite direction was observed, i.e when the trim tab was extended by 6.4 degrees the resistance was less than for the runs when the tab was retracted by 6.4 degrees.

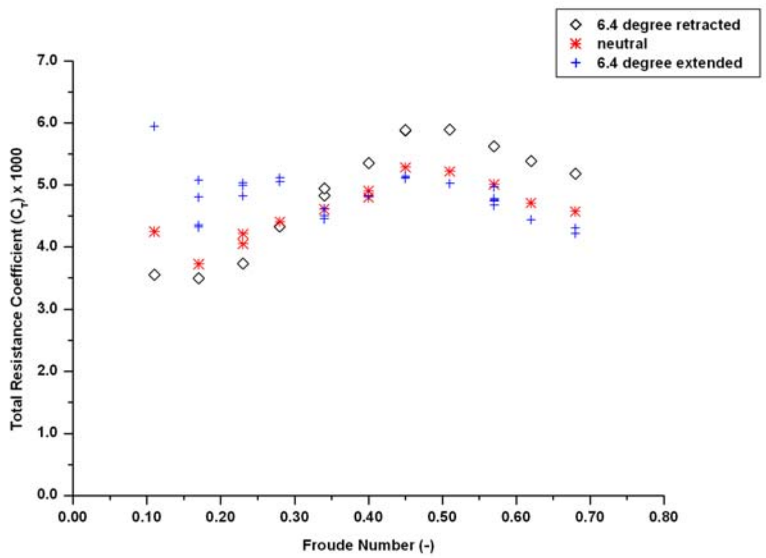


*Figure 7 Total Resistance Coefficient vs Froude Number (300.5 t displacement, 0.0 m static trim)*

Figure 8 shows the change in the running trim of the vessel versus the speed for the 300.5 t displacement, 0.0 m static trim condition. As expected, this plot shows that the angle at which the trim tab is set influences the running trim of the vessel and is most pronounced at the

higher speeds. In this report the running trim is defined as the combination of the initial static trim plus the change in trim due to forward speed.

The 6.4 degree retracted angle trim tab setting has a stern down trim for all the speeds considered. When the trim tab is in the neutral position the running trim of the vessel is slightly bow down for Froude numbers less than 0.34 (15 knots) and bow up for speeds higher than 15 knots. For the 6.4 degree extended trim tab setting, the trim of the vessel does not change from bow down to bow up until around speeds between Fr numbers equal to 0.40 to 0.45 (17.5-20 knots) but at a Fr number equal to 0.34 or 15 knots the running trim of the vessel starts to tend towards a stern down trim.

These trends in the running trim of the vessel are consistent with the trends of the total resistance coefficient. The larger the angle the vessel trims by the stern the higher the resistance. This is particularly evident at the higher speeds where the retracted trim tab setting results in both larger running trim angles and higher resistance.

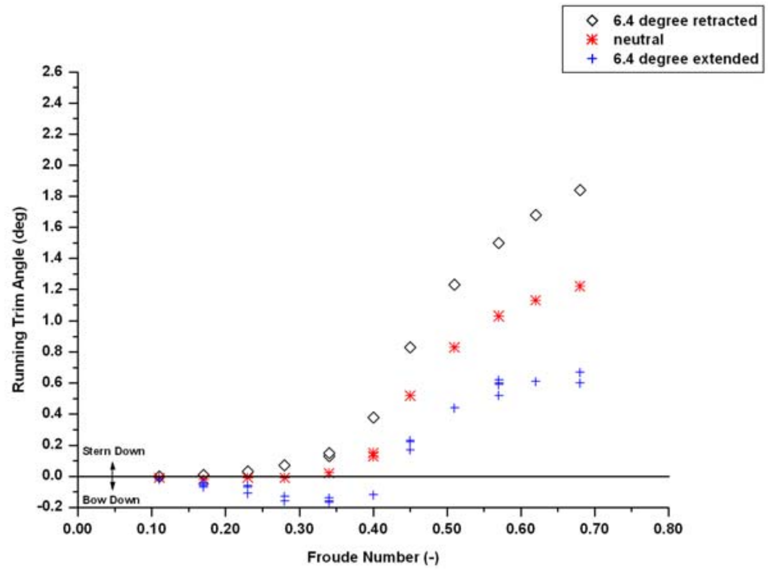


*Figure 8 Running Trim vs Froude Number (300.5 t displacement, 0.0 m static trim)*

Figure 9 shows the effect that speed has on the rise of the vessel at its centre of gravity for the three trim tab angles considered. As the angle of the trim tab changes from the retracted position to the extended position, the rise of the vessel at its centre of gravity increases.

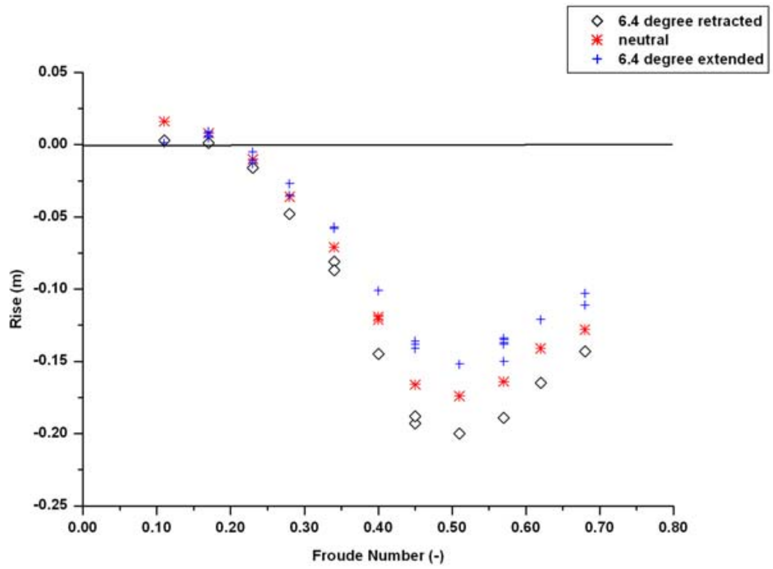


*Figure 9 Rise vs Froude Number (300.5 t displacement, 0.0 m static trim)*

Figure 10 shows a photograph of the calm water resistance test for the 300.5 t displacement, 0.0 m static trim condition. The model has a Froude number equal to 0.68 (30 knots) with a trim tab setting of 6.4 degree extended. This speed is higher than the operational speed limits of the full scale Armidale Class Patrol Boat but experiments were undertaken at these higher speeds to ensure that the upper bounds of the speed profile is clearly defined.

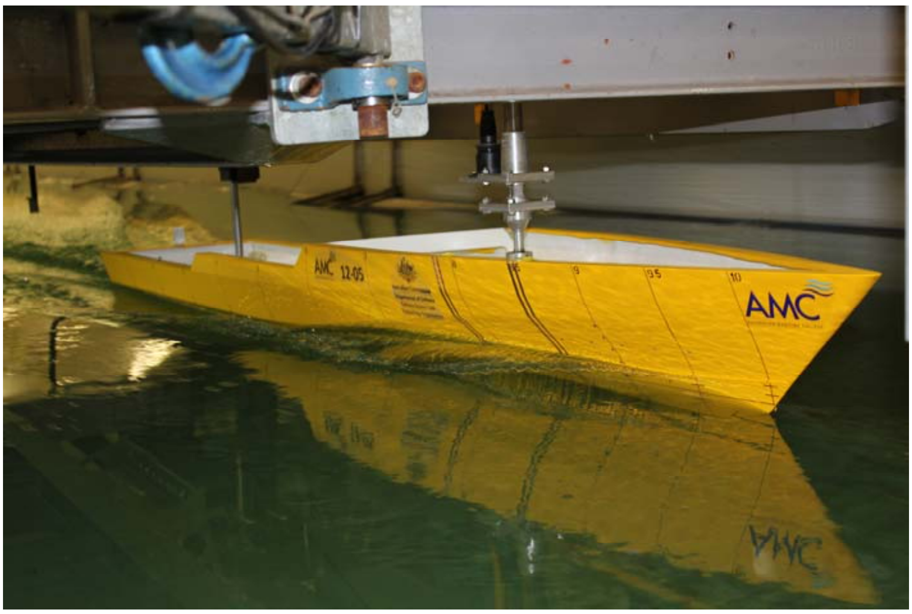


*Figure 10 Photograph of the 300.5 t displacement, 0.0 m static trim Calm Water Resistance Tests.*

Figure 11 shows a plot of the effective power extrapolated to full scale for the 300.5 t displacement, 0.0 m static trim condition versus speed for the three trim tab settings tested. It

is shown that for speeds above a Fr number equal to 0.34 or (15 knots) the effective power is higher for the retracted trim tab setting than the neutral position of the tab which in turn are both higher than the extended setting.

For speeds lower than 15 knots there is very little difference in the effective power for all the trim tab settings studied. Through out this lower speed range the trim tabs could be operated in the fully retracted position as there is no benefit in terms of effective power when operating with them extended.

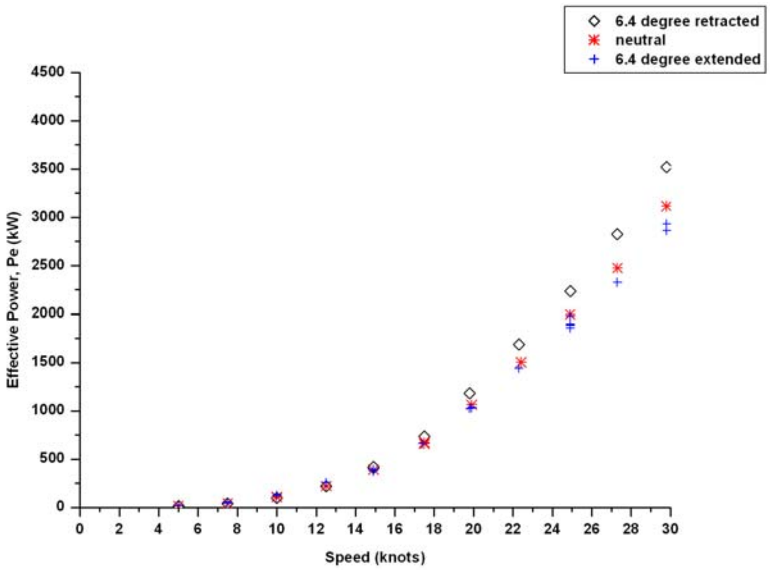


*Figure 11 Effective Power vs Speed (300.5 t displacement, 0.0 m static trim)*

## 3.2 Load Condition 2: (300.5 t displacement, 0.3 m static trim by the stern)

Figure 12 shows a plot of the Total Resistance Coefficient versus Froude Number for the 300.5 t displacement, 0.3 m static trim condition for the ACPB for the three trim tab angles tested. The trend in the resistance curve is very similar to that measured for the 300.5 t displacement, 0.0 m static trim condition, i.e. the retracted tab has lower resistance compared to the other trim tab settings at speeds below a Fr number equal to 0.34 or 15 knots whereas at speeds above 15 knots the resistance for the retracted trim tab is higher.

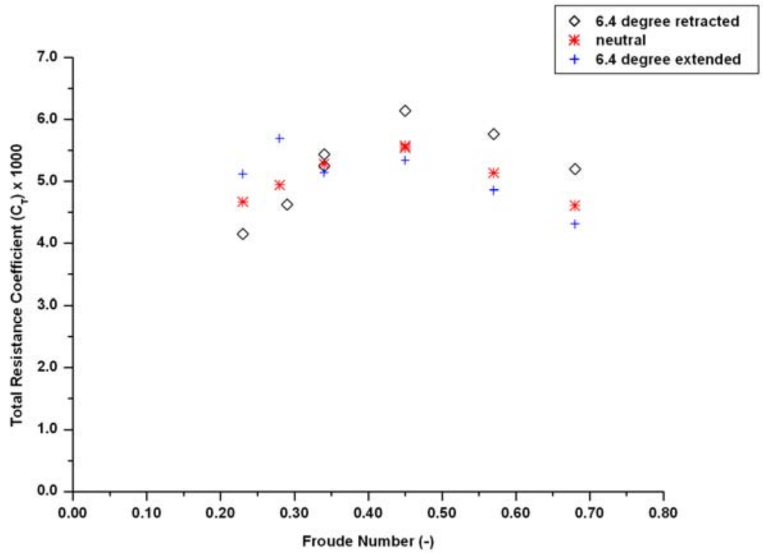


*Figure 12 Total Resistance Coefficient vs Froude Number (300.5 t displacement, 0.3 m static trim)*

The running trim versus speed plot for the 300.5 t displacement, 0.3 m static trim condition shows a very similar trend to the 300.5 t displacement, 0.0 m static trim condition, see Figure 13.

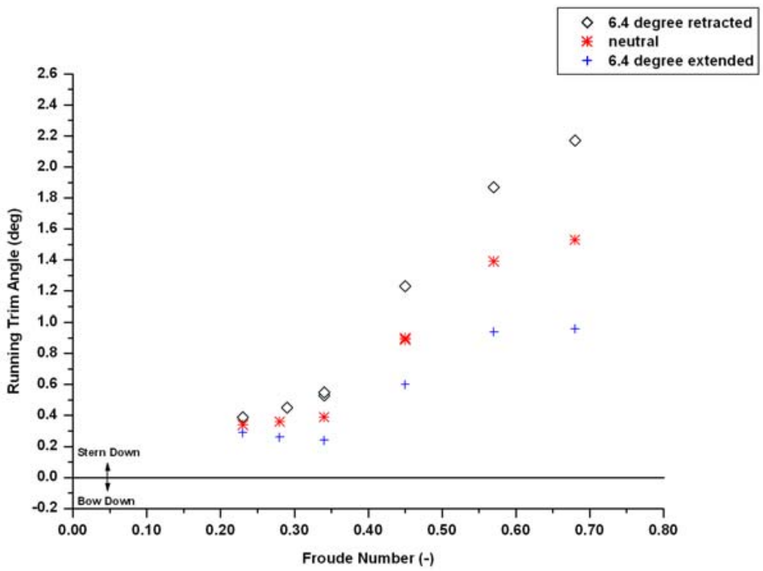


*Figure 13 Running Trim vs Froude Number (300.5 t displacement, 0.3 m static trim)*

The testing of the 300.5 t displacement, 0.3 m static trim conditions showed that when the trim tab was set in the retracted position the vessel had lower rise at the centre of gravity than when the trim tabs were extended. This is similar to that observed for the 300.5 t displacement, 0.0 m static trim condition. Figure 14 shows the rise versus speed plots for the 300.5 t displacement, 0.3 m static trim condition.

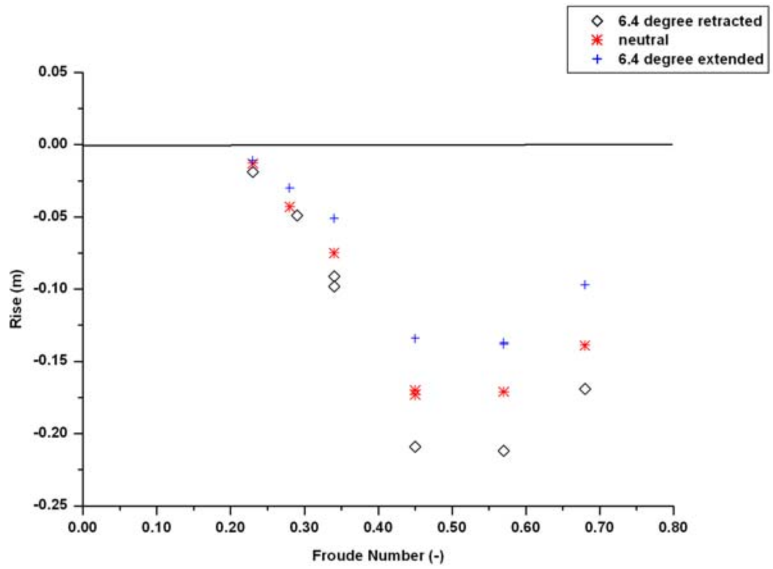


*Figure 14 Rise  vs Froude Number (300.5 t displacement, 0.3 m static trim)*

As previously observed, at speeds greater than 15 knots, the effective power is higher for the retracted trim tab condition than the neutral position of the trim tab which in turn is higher than the extended setting. The influence of the trim tab position on the effective power for the vessel is shown in Figure 15 for a range of speeds.

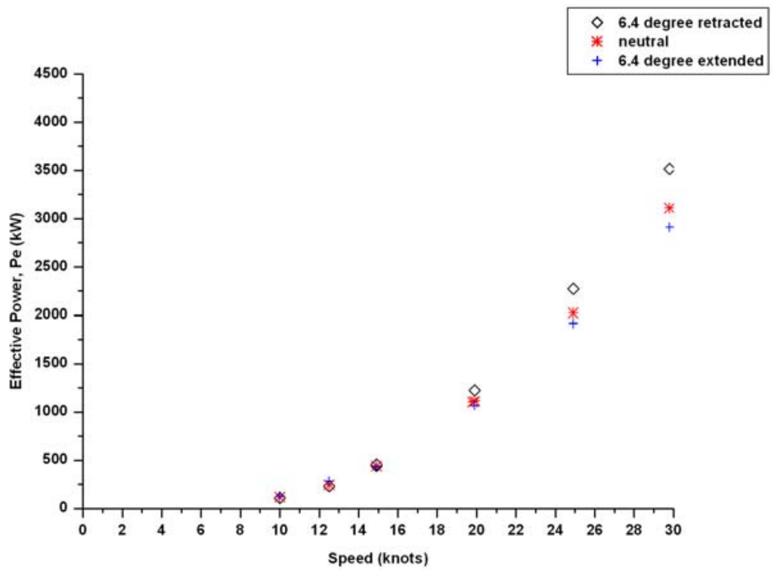


*Figure 15 Effective Power vs Speed (300.5 t displacement, 0.3 m static)*

### 3.3 Load Condition 3: (300.5 t displacement, 0.6 m static trim by the stern)

Figure 16 - Figure 19 show the total resistance coefficient, running trim and rise versus Froude number and effective power versus speed for the 300.5 t displacement, 0.6 m static trim condition. Similar trends were observed for this condition as described in previous sections.

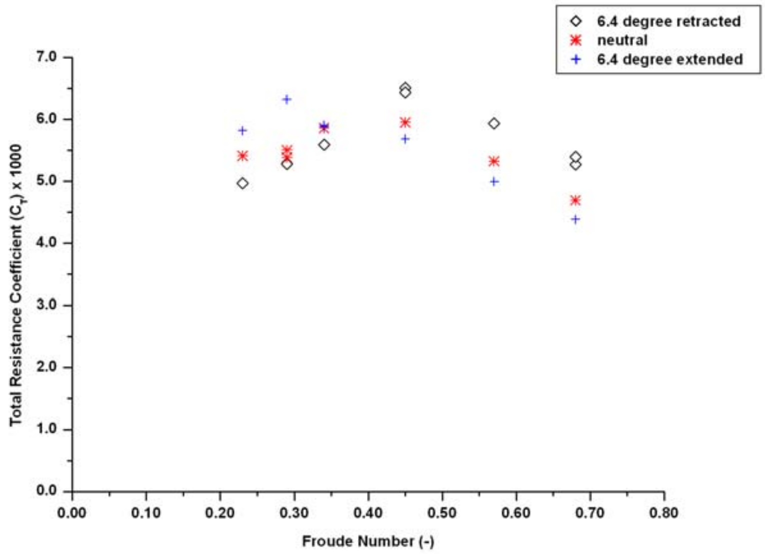


*Figure 16 Total Resistance Coefficient vs Froude Number (300.5 t displacement, 0.6 m static trim)*

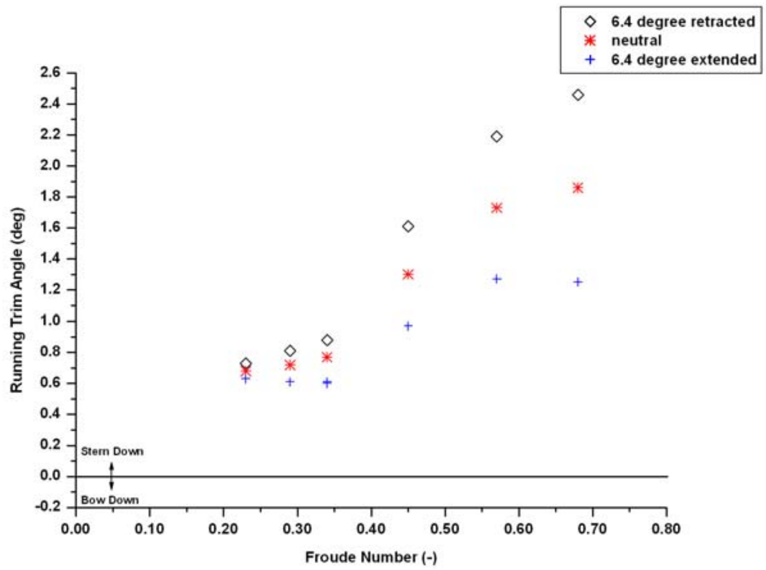


*Figure 17 Running Trim vs Froude Number (300.5 t displacement, 0.6 m static trim)*

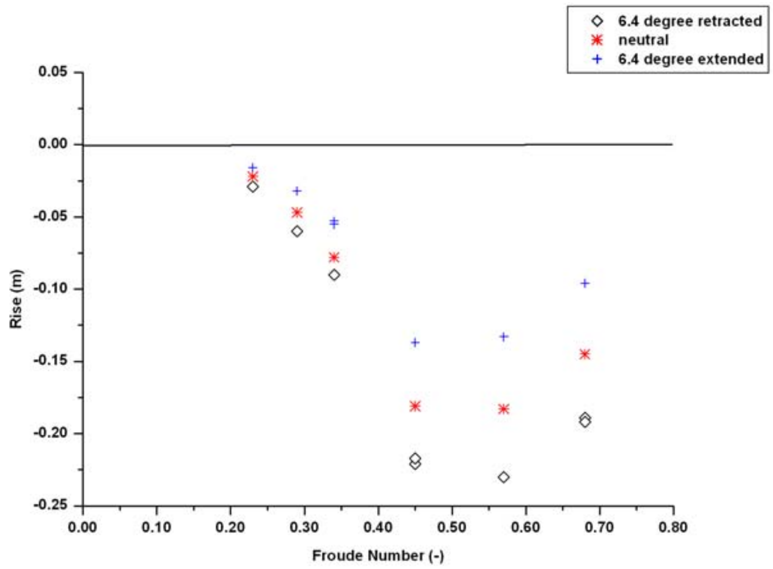


*Figure 18 Rise vs Froude Number (300.5 t displacement, 0.6 m static trim)*

Figure 19 shows that for speeds above 15 knots, the effective power is higher for the retracted trim tabs setting than the neutral position of the tab, which is in turn higher than the extended tab setting.

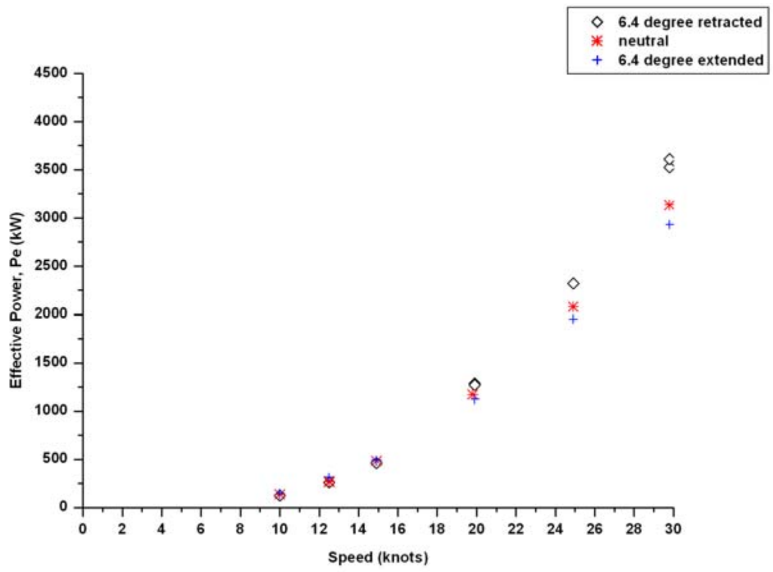


*Figure 19 Effective Power vs Froude Number (300.5 t displacement, 0.6 m static)*

## 3.4 Load Condition 4: (340.6 t displacement, 0.0 m static trim)

The following section shows the results from the experimental tests for the 340.6 t displacement, 0.0 m static trim condition. Figure 20 - Figure 23 show the total resistance coefficient, running trim and rise versus Froude number and effective power versus speed.

Although a heavier displacement and corresponding increase in resistance and hence effective power, similar trends were observed for this condition as those observed for the 300.5 t condition.

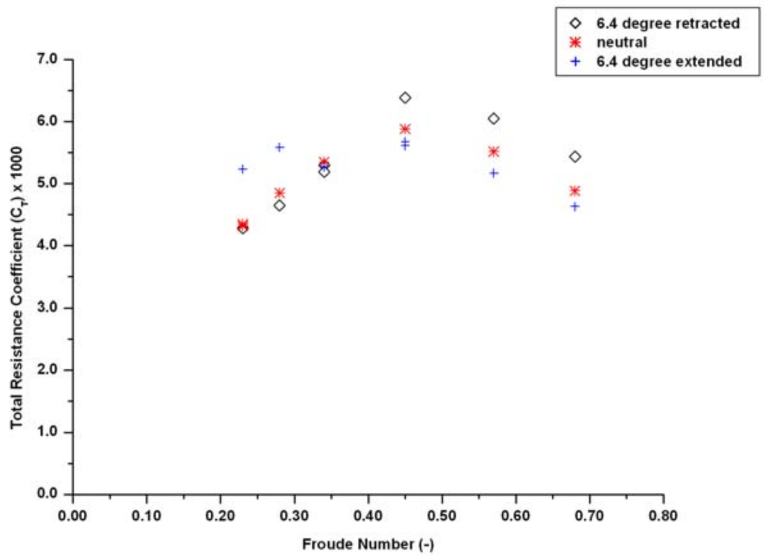


*Figure 20 Total Resistance Coefficient vs Froude Number (340.6 t, 0.0 m static trim)*

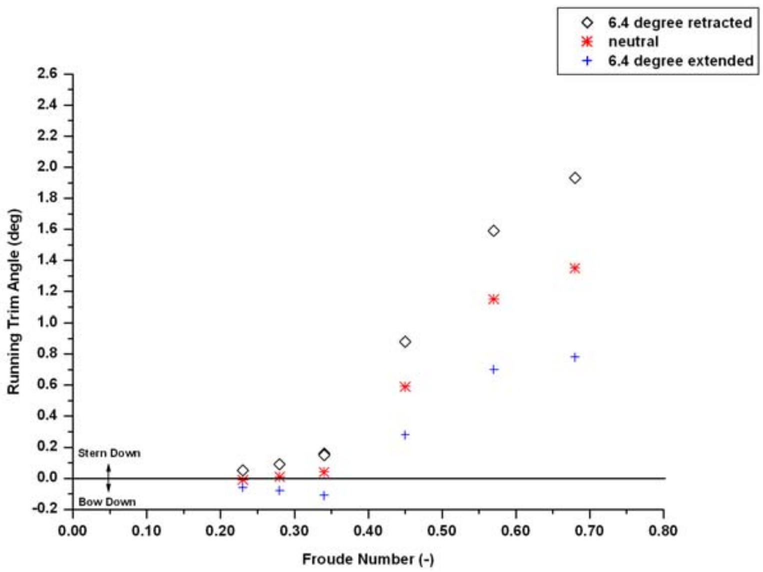


*Figure 21 Running Trim vs Froude Number (340.6 t displacement, 0.0 m static trim)*

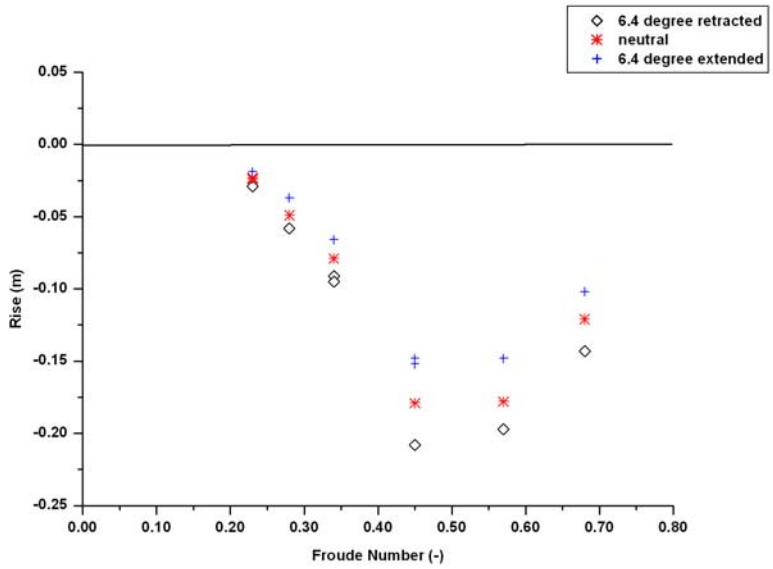


*Figure 22 Rise vs Froude Number (340.6 t displacement, 0.0 m static trim)*

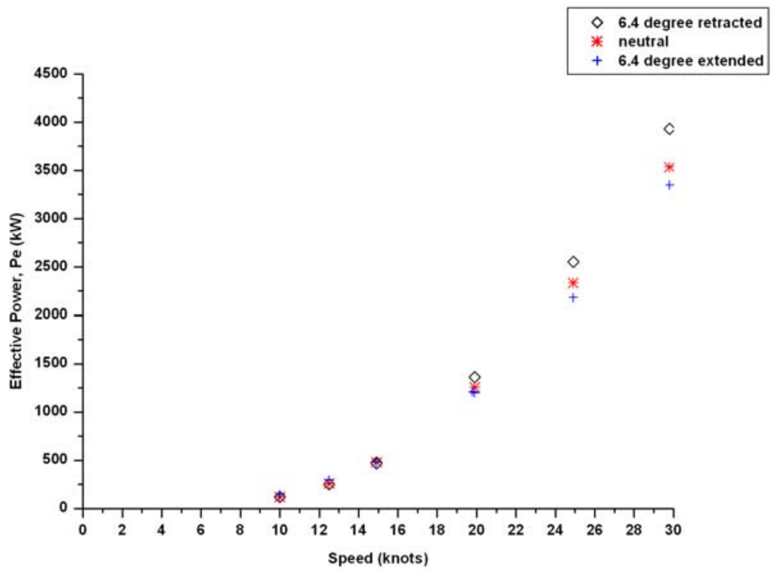


*Figure 23 Effective Power vs Speed (340.6 t displacement, 0.0 m static trim)*

## 3.5 Load Condition 5: (240.4 t displacement, 0.0 m static trim)

Tests were also performed for a 240.4 t displacement, 0.0 m static trim condition. Figure 24 - Figure 27 show the total resistance coefficient, running trim and rise versus Froude number and effective power versus speed. Similar trends were observed for this condition as those observed for both the 300.5 t and 340.6 t conditions.

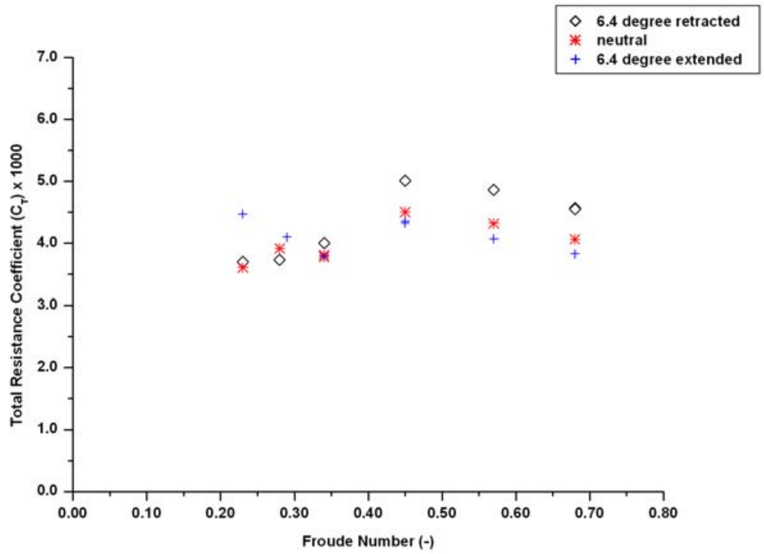


*Figure 24 Total Resistance Coefficient vs Froude Number (240.4 t, 0.0 m static trim)*

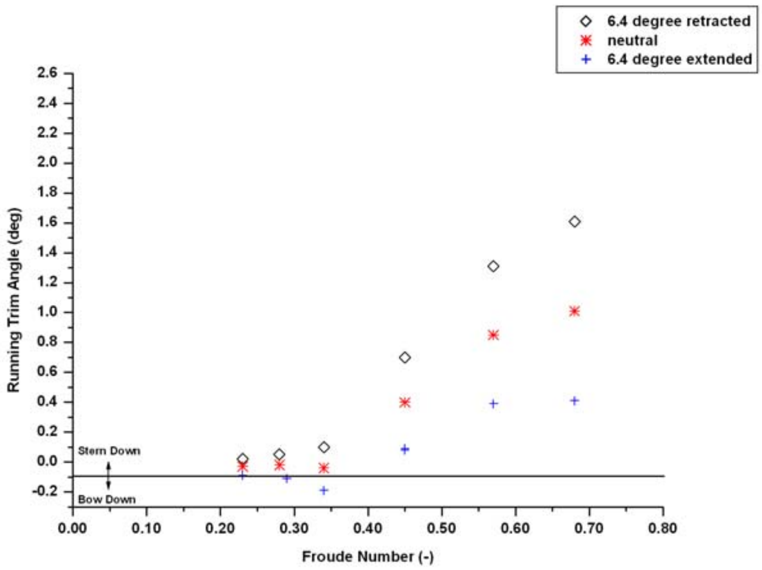


*Figure 25 Running Trim vs Froude Number (240.4 t displacement, 0.0 m static trim)*

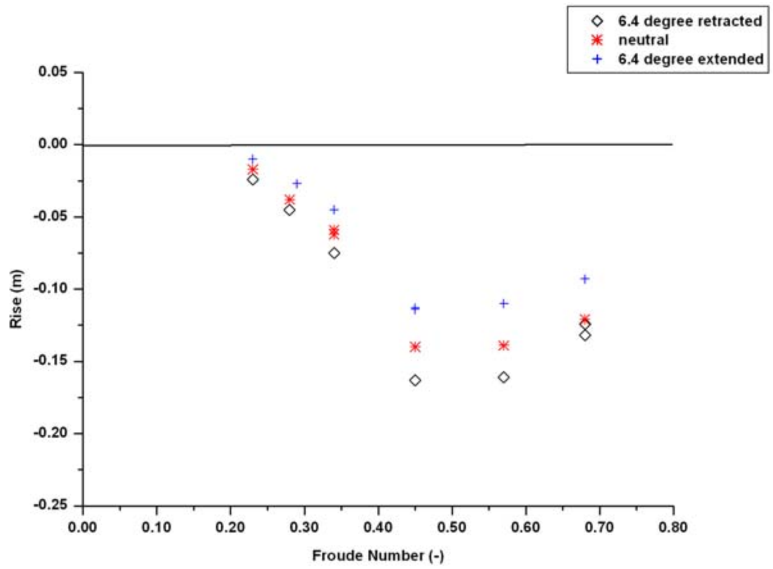


*Figure 26 Rise vs Froude Number (240.4 t displacement, 0.0 m static trim)*

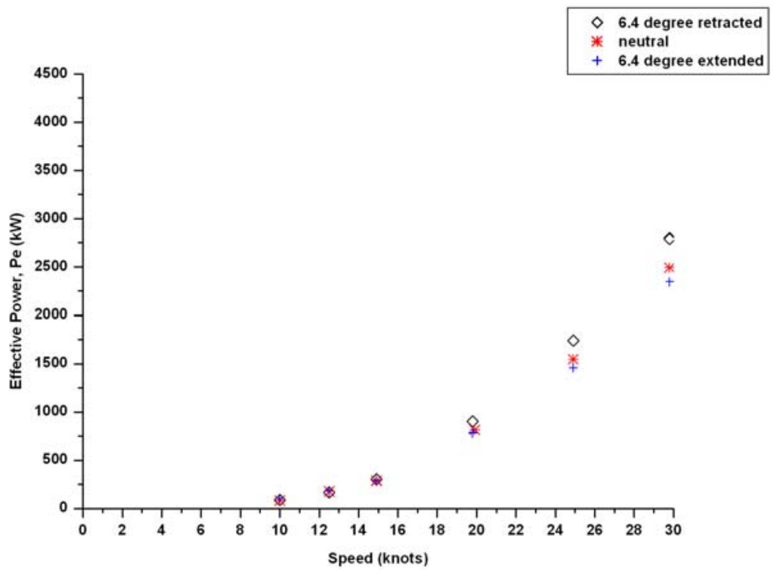


*Figure 27 Effective Power vs Speed (240.4 t displacement, 0.0 m static trim)*

## 3.6 Load Condition 1: (300.5 t displacement, 0.0 m static trim, with/without appendages, trim tab neutral)

A series of tests were undertaken to determine the effect that appendages had on the resistance coefficient, running trim, rise and effective power of the vessel. The added appendages are as detailed in Section 3.2.1. Rudders and roll stabiliser fins were aligned fore and aft on the model and hence not necessarily exactly aligned with the local flow direction. These tests were undertaken for the 300.5 t displacement, 0.0 m static trim condition with the trim tab set in the neutral position. Figure 28 shows the comparison between the results

obtained for total resistance coefficient of the ship with appendages compared to the ship without appendages. The resistance coefficient is slightly higher for the appended hull at the lower speed range (less than Froude No equal to 0.34), but at higher speeds the difference was negligible. This shows that the contribution that the appendages make to the total resistance coefficient is negligible at the higher speeds.

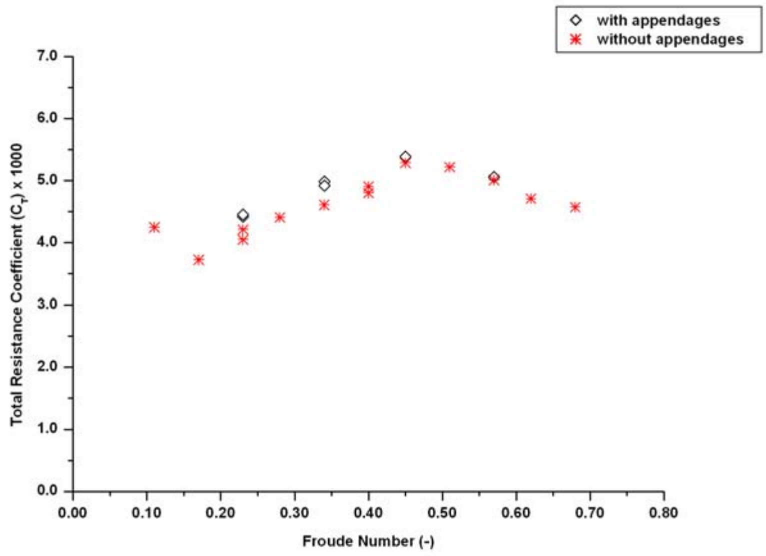


*Figure 28 Total Resistance Coefficient vs Froude Number (300.5 t displacement, 0.0 m static trim, with and without appendages)*

When comparing the running trim of the vessel, this was slightly higher on the appended hull whereas there was very little difference observed in the rise between the appended and unappended hull across the speed range tested. These comparisons are shown in Figure 29 - Figure 30.

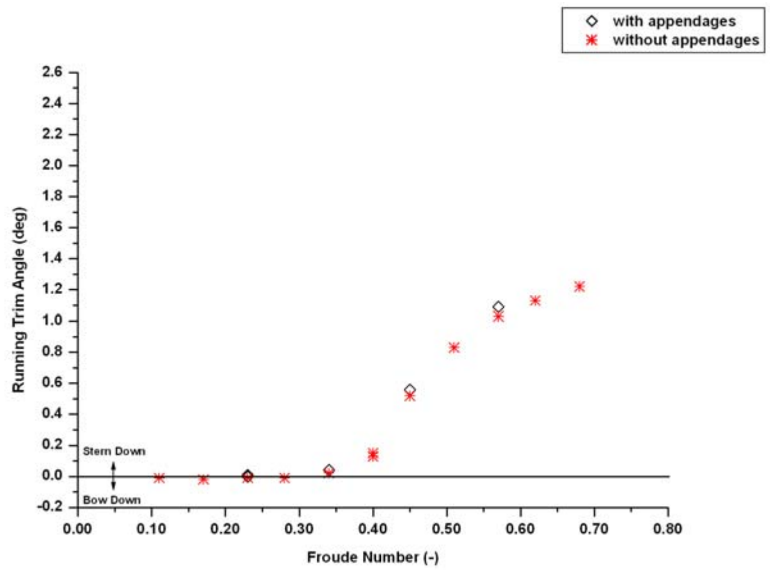


*Figure 29 Running Trim vs Froude Number (300.5 t displacement, 0.0 m static trim, with and without appendages)*

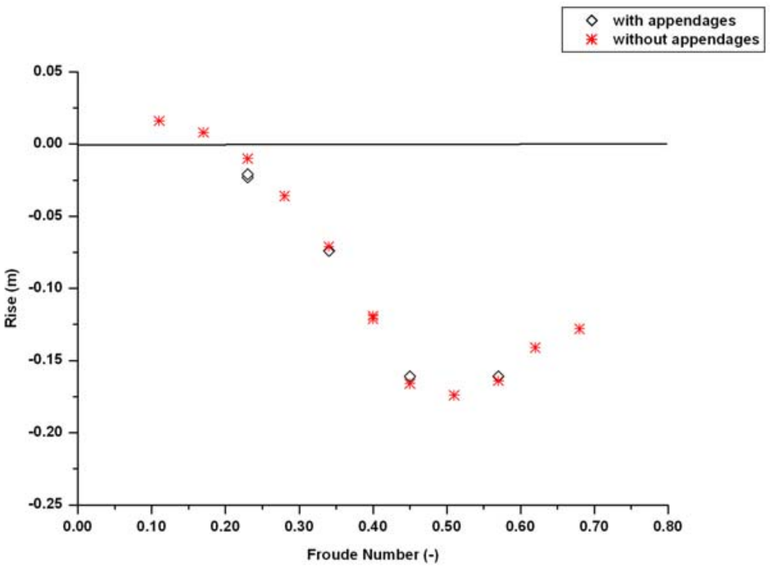


*Figure 30 Rise vs Froude Number (300.5 t displacement, 0.0 m static trim, with and without appendages)*

As expected the effective power required for the appended hull is always higher than the unappended. Figure 31 shows a comparison of the effective power for both the appended and unappended hull.

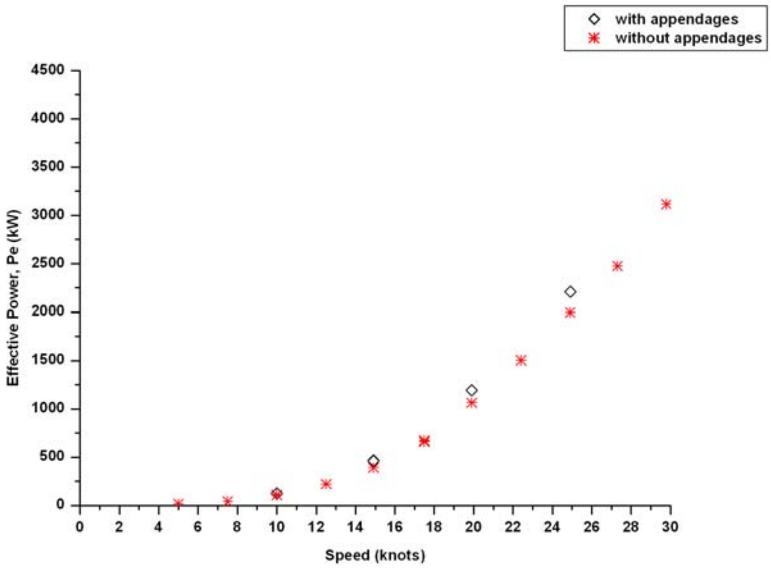


*Figure 31 Effective Power vs Speed (300.5 t displacement, 0.0 m static trim, with and without appendages)*

# 4. Conclusion

This report has shown the outcomes of the calm water resistance tests for a 1:25 scale model of the ACPB that has recently been undertaken by DSTO and DNPS at the Towing Tank facility of The Australian Maritime College. The experimental program studied the influence that the angle of the stern trim tabs had on total resistance coefficient, running trim angle, rise and effective power for the ACPB model across a range of speeds, static trims and displacements. Three trim tab settings were studied: (1) retracted by 6.4 degree from the neutral, (2) tab parallel to the baseline along the neutral line and (3) the trim tab extended by 6.4 degree from the neutral.

Outcomes from this study showed that, for all load conditions tested, when the speed of the vessel was less than 15 knots, the lowest resistance was recorded when the trim tab was in the retracted position. For speeds greater than 15 knots, an extended trim tab resulted in the lowest resistance.

It was observed that the dynamic trim of the vessel was influenced by the angle at which the trim tab was set. When the trim tab was in the retracted position, the ACPB always had a stern down trim across the entire speed range tested. When the trim tab was set in the neutral position, the ACPB had a bow down trim for speeds less than 15 knots and a stern down trim for speeds greater than 15 knots. When the trim tab was extended the speed, at which the ACPB changed from a bow down trim to a stern down trim increased to between 17.5 and 20 knots.

For all load conditions and speeds tested, the rise of the vessel increased as the angle of the trim changed from retracted to extended.

For speeds greater than 15 knots, the effective power was higher when the trim tabs were set in the retracted position when compared to the neutral position which in turn was higher than for the extended setting. For speeds lower than 15 knots there is very little difference in the effective power for all the trim tab settings studied. Through out this lower speed range the trim tabs could be operated in the fully retracted position as there is no benefit in terms of effective power when operating with them extended.

The data obtained during this experimental study will be used as a validation dataset for ongoing development of a suite of numerical tools to model the resistance, seakeeping and operational slamming loads on semi-planing hullforms like the Armidale Class Patrol Boat. Knowledge gained from this research program will also be used by DNPS to provide advice to the Royal Australian Navy in regards to the optimal manner to operate the ACPB's to minimise fuel consumption.

# 5. Acknowledgements

The authors acknowledge the valuable input from both Mr Ed Dawson, DSTO, and Mr Martin Grimm, DNPS in both the preparation for this experimental program and throughout the course of this research program. Acknowledgement made of the staff at The Australian Maritime College for their input and assistance whilst undertaking the experimental component of this work.

# 6. References

1. http://www.defence.gov.au/SRP/.
2. Savitsky, D. (1985) Planing Craft. *Naval Engineers Journal* **Chapter IV**
3. Fletcher, L. S., Vincent, P. and Wilson, A. (2009) *Implications for Performance and Fuel Consumption Caused by Biofouling on ACPBs*. DSTO-TN-0925, Australia, DSTO
4. *International Towing Tank Conference ITTC Recommended Procedures and Guidelines 7.5-01-01-01*. (2002) Model Manufacture - Ship Models,
5. *Austal Drawing No. 321-100-101 Rev F General Arranagement*.
6. *Austal Drawing No. 321-299-002 Rev B Lines Plan*.
7. *Austal Drawing No. 321-299-010 Rev X Spray Rail Details*.
8. *Austal Drawing No. 321-299-013 Rev Y Skeg Construction Details*.
9. *Austal Drawing No. 326-299-014 Rev A Bilge Keel Construction Details*.
10. *Austal Drawing No. 321-506-010 Rev Y Aft Trim Tab Detail*.
11. *Austal Drawing No. 321-201E-061 Rev X Midship Ride Control Support Structure*.
12. Armidale Class Patrol Boat (ACPB) Stability Report, A017163 Royal Australian Navy, Dec 2009.
13. *Recommended Procedures for the Conduct of Standard Experiments within the AMC Towing Tank and Model Test Basin*. (2009) Australian Maritime College,
14. *International Towing Tank Conference ITTC Recommended Procedures and Guidelines 7.5-02-02-01*. (2002) Testing and Evaluation Methods Resistance - Resistance Tests,

*This page is intentionally blank*

# Appendix A: Calm Water Resistance Test Matrix

Load Condition 1 (Full Scale 300.5 t, 0.0 m trim)

| | Model Scale | | | | | Full Scale (Ship) | | | |
|---|---|---|---|---|---|---|---|---|---|
| Run Number | Displacement (kg) | Static Trim (m) | Model Speed (m/s) | Trim Tab Setting | Comment | Displacement (t) | Static Trim (m) | Speed (knts) | Froude Number (Fn) |
| 41 | | | 0.51 | | | | | 5.0 | 0.11 |
| 42 | | | 0.77 | | | | | 7.5 | 0.17 |
| 43 | | | 1.03 | | | | | 10.0 | 0.23 |
| 44 | | | 1.29 | | | | | 12.5 | 0.28 |
| 45 | | | 1.54 | | | | | 15.0 | 0.34 |
| 46 | | | 1.80 | | | | | 17.5 | 0.40 |
| 47 | 18.732 | 0.0 | 2.06 | Retracted 6.4° | | 300.5 | 0.0 | 20.0 | 0.45 |
| 48 | | | 2.31 | | | | | 22.5 | 0.51 |
| 49 | | | 2.57 | | | | | 25.0 | 0.57 |
| 50 | | | 2.83 | | | | | 27.5 | 0.62 |
| 51 | | | 3.09 | | | | | 30.0 | 0.68 |
| 52 | | | 2.06 | | Repeat | | | 20.0 | 0.45 |
| 53 | | | 1.54 | | Repeat | | | 15.0 | 0.34 |
| 28 | | | 0.51 | | | | | 5.0 | 0.11 |
| 29 | | | 0.77 | | | | | 7.5 | 0.17 |
| 30 | | | 1.03 | | | | | 10.0 | 0.23 |
| 31 | | | 1.29 | | | | | 12.5 | 0.28 |
| 32 | | | 1.54 | | | | | 15.0 | 0.34 |
| 33 | | | 1.80 | | | | | 17.5 | 0.40 |
| 34 | 18.732 | 0.0 | 2.06 | neutral | | 300.5 | 0.0 | 20.0 | 0.45 |
| 35 | | | 2.31 | | | | | 22.5 | 0.51 |
| 36 | | | 2.57 | | | | | 25.0 | 0.57 |
| 37 | | | 2.83 | | | | | 27.5 | 0.62 |
| 38 | | | 3.09 | | | | | 30.0 | 0.68 |
| 39 | | | 1.03 | | Repeat | | | 10.0 | 0.23 |
| 40 | | | 1.80 | | Repeat | | | 17.5 | 0.40 |
| 5 | | | 0.51 | | | | | 5.0 | 0.11 |
| 6 | | | 0.77 | | | | | 7.5 | 0.17 |
| 7 | | | 1.03 | | | | | 10.0 | 0.23 |
| 8 | | | 1.29 | | | | | 12.5 | 0.28 |
| 9 | | | 1.54 | | | | | 15.0 | 0.34 |
| 10 | | | 1.80 | | | | | 17.5 | 0.40 |
| 11 | | | 2.06 | | | | | 20.0 | 0.45 |
| 12 | | | 2.31 | | | | | 22.5 | 0.51 |
| 13 | | | 2.57 | | | | | 25.0 | 0.57 |
| 14 | | | 2.83 | | | | | 27.5 | 0.62 |
| 15 | | | 3.09 | | | | | 30.0 | 0.68 |
| 16 | | | 0.77 | | Repeat | | | 7.5 | 0.17 |
| 17 | | | 1.54 | | Repeat | | | 15.0 | 0.34 |
| 1 | 18.732 | 0.0 | 1.29 | Extended 6.4° | No tape | 300.5 | 0.0 | 12.5 | 0.28 |
| 2 | | | 2.57 | | No tape | | | 25.0 | 0.57 |
| 3 | | | 2.57 | | tape | | | 25.0 | 0.57 |
| 4 | | | 2.57 | | tape | | | 25.0 | 0.57 |
| 18 | | | 0.77 | | | | | 7.5 | 0.17 |
| 19 | | | 0.77 | | | | | 7.5 | 0.17 |
| 20 | | | 1.03 | | | | | 10.0 | 0.23 |
| 21 | | | 1.54 | | | | | 15.0 | 0.34 |
| 22 | | | 2.06 | | | | | 20.0 | 0.45 |
| 23 | | | 2.57 | | | | | 25.0 | 0.57 |
| 24 | | | 1.03 | | | | | 10.0 | 0.23 |
| 25 | | | 2.06 | | | | | 20.0 | 0.45 |
| 26 | | | 2.57 | | | | | 25.0 | 0.57 |
| 27 | | | 3.09 | | | | | 30.0 | 0.68 |

Load Condition 2 (Full Scale 300.5 t, 0.3 m trim by the stern)

| | Model Scale | | | | | Full Scale (Ship) | | | |
|---|---|---|---|---|---|---|---|---|---|
| Run Number | Displacement (kg) | Static Trim (m) | Model Speed (m/s) | Trim Tab Setting | Comment | Displacement (t) | Static Trim (m) | Speed (knts) | Froude Number (Fn) |
| 54 | | | 1.03 | | | | | 10.0 | 0.23 |
| 55 | | | 1.29 | | | | | 12.5 | 0.28 |
| 56 | | | 1.54 | | | | | 15.0 | 0.34 |
| 57 | 18.732 | 0.012 | 2.06 | Retracted 6.4° | | 300.5 | 0.3 | 20.0 | 0.45 |
| 58 | | | 2.57 | | | | | 25.0 | 0.57 |
| 59 | | | 3.09 | | | | | 30.0 | 0.68 |
| 60 | | | 1.54 | | Repeat | | | 15.0 | 0.34 |
| 61 | | | 1.03 | | | | | 10.0 | 0.23 |
| 62 | | | 1.29 | | | | | 12.5 | 0.28 |
| 63 | | | 1.54 | | | | | 15.0 | 0.34 |
| 64 | 18.732 | 0.012 | 2.06 | neutral | | 300.5 | 0.3 | 20.0 | 0.45 |
| 65 | | | 2.57 | | | | | 25.0 | 0.57 |
| 66 | | | 3.09 | | | | | 30.0 | 0.68 |
| 67 | | | 2.06 | | Repeat | | | 20.0 | 0.45 |
| 68 | | | 1.03 | | | | | 10.0 | 0.23 |
| 69 | | | 1.29 | | | | | 12.5 | 0.28 |
| 70 | | | 1.54 | | | | | 15.0 | 0.34 |
| 71 | 18.732 | 0.012 | 2.06 | Extended 6.4° | | 300.5 | 0.3 | 20.0 | 0.45 |
| 72 | | | 2.57 | | | | | 25.0 | 0.57 |
| 73 | | | 3.09 | | | | | 30.0 | 0.68 |
| 74 | | | 2.57 | | Repeat | | | 25.0 | 0.57 |

Load Condition 3 (Full Scale 300.5 t, 0.6 m trim by the stern)

| | Model Scale | | | | | Full Scale (Ship) | | | |
|---|---|---|---|---|---|---|---|---|---|
| Run Number | Displacement (kg) | Static Trim (m) | Model Speed (m/s) | Trim Tab Setting | Comment | Displacement (t) | Static Trim (m) | Speed (knts) | Froude Number (Fn) |
| 89 | | | 1.03 | | | | | 10.0 | 0.23 |
| 90 | | | 1.29 | | | | | 12.5 | 0.28 |
| 91 | | | 1.54 | | | | | 15.0 | 0.34 |
| 92 | | | 2.06 | | | | | 20.0 | 0.45 |
| 93 | 18.732 | 0.024 | 2.57 | Retracted 6.4° | | 300.5 | 0.6 | 25.0 | 0.57 |
| 94 | | | 3.09 | | | | | 30.0 | 0.68 |
| 95 | | | 2.06 | | Repeat | | | 20.0 | 0.45 |
| 96 | | | 3.09 | | Air Resistance | | | 30.0 | 0.68 |
| 82 | | | 1.03 | | | | | 10.0 | 0.23 |
| 83 | | | 1.29 | | | | | 12.5 | 0.28 |
| 84 | | | 1.54 | | | | | 15.0 | 0.34 |
| 85 | 18.732 | 0.024 | 2.06 | neutral | | 300.5 | 0.6 | 20.0 | 0.45 |
| 86 | | | 2.57 | | | | | 25.0 | 0.57 |
| 87 | | | 3.09 | | | | | 30.0 | 0.68 |
| 88 | | | 1.29 | | Repeat | | | 12.5 | 0.28 |
| 75 | | | 1.03 | | | | | 10.0 | 0.23 |
| 76 | | | 1.29 | | | | | 12.5 | 0.28 |
| 77 | | | 1.54 | | | | | 15.0 | 0.34 |
| 78 | 18.732 | 0.024 | 2.06 | Extended 6.4° | | 300.5 | 0.6 | 20.0 | 0.45 |
| 79 | | | 2.57 | | | | | 25.0 | 0.57 |
| 80 | | | 3.09 | | | | | 30.0 | 0.68 |
| 81 | | | 1.54 | | Repeat | | | 15.0 | 0.34 |

Load Condition 4 (Full Scale 340.6 t, 0.0 m trim)

| | Model Scale | | | | | Full Scale (Ship) | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Run Number** | **Displacement (kg)** | **Static Trim (m)** | **Model Speed (m/s)** | **Trim Tab Setting** | **Comment** | **Displacement (t)** | **Static Trim (m)** | **Speed (knts)** | **Froude Number (Fn)** |
| 97 | 21.229 | 0.0 | 1.03 | Retracted 6.4° | aborted | 340.6 | 0.0 | 10.0 | 0.23 |
| 98 | 21.229 | 0.0 | 1.03 | Retracted 6.4° | | 340.6 | 0.0 | 10.0 | 0.23 |
| 99 | 21.229 | 0.0 | 1.29 | Retracted 6.4° | | 340.6 | 0.0 | 12.5 | 0.28 |
| 100 | 21.229 | 0.0 | 1.54 | Retracted 6.4° | | 340.6 | 0.0 | 15.0 | 0.34 |
| 101 | 21.229 | 0.0 | 2.06 | Retracted 6.4° | | 340.6 | 0.0 | 20.0 | 0.45 |
| 102 | 21.229 | 0.0 | 2.57 | Retracted 6.4° | | 340.6 | 0.0 | 25.0 | 0.57 |
| 103 | 21.229 | 0.0 | 3.09 | Retracted 6.4° | | 340.6 | 0.0 | 30.0 | 0.68 |
| 104 | 21.229 | 0.0 | 1.54 | Retracted 6.4° | Repeat | 340.6 | 0.0 | 15.0 | 0.34 |
| 105 | 21.229 | 0.0 | 1.03 | neutral | | 340.6 | 0.0 | 10.0 | 0.23 |
| 106 | 21.229 | 0.0 | 1.29 | neutral | | 340.6 | 0.0 | 12.5 | 0.28 |
| 107 | 21.229 | 0.0 | 1.54 | neutral | | 340.6 | 0.0 | 15.0 | 0.34 |
| 108 | 21.229 | 0.0 | 2.06 | neutral | | 340.6 | 0.0 | 20.0 | 0.45 |
| 109 | 21.229 | 0.0 | 2.57 | neutral | | 340.6 | 0.0 | 25.0 | 0.57 |
| 110 | 21.229 | 0.0 | 3.09 | neutral | | 340.6 | 0.0 | 30.0 | 0.68 |
| 111 | 21.229 | 0.0 | 1.03 | neutral | Repeat | 340.6 | 0.0 | 10.0 | 0.23 |
| 112 | 21.229 | 0.0 | 1.03 | Extended 6.4° | | 340.6 | 0.0 | 10.0 | 0.23 |
| 113 | 21.229 | 0.0 | 1.29 | Extended 6.4° | | 340.6 | 0.0 | 12.5 | 0.28 |
| 114 | 21.229 | 0.0 | 1.54 | Extended 6.4° | | 340.6 | 0.0 | 15.0 | 0.34 |
| 115 | 21.229 | 0.0 | 2.06 | Extended 6.4° | | 340.6 | 0.0 | 20.0 | 0.45 |
| 116 | 21.229 | 0.0 | 2.57 | Extended 6.4° | | 340.6 | 0.0 | 25.0 | 0.57 |
| 117 | 21.229 | 0.0 | 3.09 | Extended 6.4° | | 340.6 | 0.0 | 30.0 | 0.68 |
| 118 | 21.229 | 0.0 | 2.06 | Extended 6.4° | Repeat | 340.6 | 0.0 | 20.0 | 0.45 |

Load Condition 5 (Full Scale 240.4 t, 0.0 m trim)

| | Model Scale | | | | | Full Scale (Ship) | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Run Number** | **Displacement (kg)** | **Static Trim (m)** | **Model Speed (m/s)** | **Trim Tab Setting** | **Comment** | **Displacement (t)** | **Static Trim (m)** | **Speed (knts)** | **Froude Number (Fn)** |
| 126 | 14.985 | 0.0 | 1.03 | Retracted 6.4° | | 240.4 | 0.0 | 10.0 | 0.23 |
| 127 | 14.985 | 0.0 | 1.29 | Retracted 6.4° | | 240.4 | 0.0 | 12.5 | 0.28 |
| 128 | 14.985 | 0.0 | 1.54 | Retracted 6.4° | | 240.4 | 0.0 | 15.0 | 0.34 |
| 129 | 14.985 | 0.0 | 2.06 | Retracted 6.4° | | 240.4 | 0.0 | 20.0 | 0.45 |
| 130 | 14.985 | 0.0 | 2.57 | Retracted 6.4° | | 240.4 | 0.0 | 25.0 | 0.57 |
| 131 | 14.985 | 0.0 | 3.09 | Retracted 6.4° | | 240.4 | 0.0 | 30.0 | 0.68 |
| 132 | 14.985 | 0.0 | 3.09 | Retracted 6.4° | Repeat | 240.4 | 0.0 | 30.0 | 0.68 |
| 133 | 14.985 | 0.0 | 1.03 | neutral | | 240.4 | 0.0 | 10.0 | 0.23 |
| 134 | 14.985 | 0.0 | 1.29 | neutral | | 240.4 | 0.0 | 12.5 | 0.28 |
| 135 | 14.985 | 0.0 | 1.54 | neutral | | 240.4 | 0.0 | 15.0 | 0.34 |
| 136 | 14.985 | 0.0 | 2.06 | neutral | | 240.4 | 0.0 | 20.0 | 0.45 |
| 137 | 14.985 | 0.0 | 2.57 | neutral | | 240.4 | 0.0 | 25.0 | 0.57 |
| 138 | 14.985 | 0.0 | 3.09 | neutral | | 240.4 | 0.0 | 30.0 | 0.68 |
| 139 | 14.985 | 0.0 | 1.54 | neutral | Repeat | 240.4 | 0.0 | 15.0 | 0.34 |
| 119 | 14.985 | 0.0 | 1.03 | Extended 6.4° | | 240.4 | 0.0 | 10.0 | 0.23 |
| 120 | 14.985 | 0.0 | 1.29 | Extended 6.4° | | 240.4 | 0.0 | 12.5 | 0.28 |
| 121 | 14.985 | 0.0 | 1.54 | Extended 6.4° | | 240.4 | 0.0 | 15.0 | 0.34 |
| 122 | 14.985 | 0.0 | 2.06 | Extended 6.4° | | 240.4 | 0.0 | 20.0 | 0.45 |
| 123 | 14.985 | 0.0 | 2.57 | Extended 6.4° | | 240.4 | 0.0 | 25.0 | 0.57 |
| 124 | 14.985 | 0.0 | 3.09 | Extended 6.4° | | 240.4 | 0.0 | 30.0 | 0.68 |
| 125 | 14.985 | 0.0 | 2.06 | Extended 6.4° | Repeat | 240.4 | 0.0 | 20.0 | 0.45 |

Load Condition 1 – (appended) (Full Scale 300.5 t, 0.0 m trim with appendages)

| | Model Scale | | | | | Full Scale (Ship) | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Run Number** | **Displacement (kg)** | **Static Trim (m)** | **Model Speed (m/s)** | **Trim Tab Setting** | **Comment** | **Displacement (t)** | **Static Trim (m)** | **Speed (knts)** | **Froude Number (Fn)** |
| 140 | 18.732 | 0.0 | 1.03 | neutral | With appendages | 300.5 | 0.0 | 10.0 | 0.23 |
| 141 | | | 1.03 | | With appendages | | | 10.0 | 0.23 |
| 142 | | | 1.54 | | With appendages | | | 15.0 | 0.34 |
| 143 | | | 1.54 | | With appendages | | | 15.0 | 0.34 |
| 144 | | | 2.06 | | With appendages | | | 20.0 | 0.45 |
| 145 | | | 2.57 | | With appendages | | | 25.0 | 0.57 |

**DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION**
**DOCUMENT CONTROL DATA**

1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)

| | |
|---|---|
| 2. TITLE<br><br>Calm Water Resistance of a 1:25 Scale Model of the Armidale Class Patrol Boat | 3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION)<br><br>Document (U)<br>Title (U)<br>Abstract (U) |
| 4. AUTHOR(S)<br><br>Terry Turner And John McKillop | 5. CORPORATE AUTHOR<br><br>DSTO Defence Science and Technology Organisation<br>506 Lorimer St<br>Fishermans Bend Victoria 3207 Australia |

| 6a. DSTO NUMBER | 6b. AR NUMBER | 6c. TYPE OF REPORT | 7. DOCUMENT DATE |
|---|---|---|---|
| DSTO-TR-2768 | AR-015-447 | Technical Report | November 2012 |

| 8. FILE NUMBER | 9. TASK NUMBER | 10. TASK SPONSOR | 11. NO. OF PAGES | 12. NO. OF REFERENCES |
|---|---|---|---|---|
| 2012/1131914/1 | NAV 07/359 | DGENG | 32 | 6 |

| 13. DSTO Publications Repository | 14. RELEASE AUTHORITY |
|---|---|
| http://dspace.dsto.defence.gov.au/dspace/ | Chief, Maritime Platforms Division |

15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT

*Approved for public release*

OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE, PO BOX 1500, EDINBURGH, SA 5111

16. DELIBERATE ANNOUNCEMENT

No Limitations

17. CITATION IN OTHER DOCUMENTS Yes

18. DSTO RESEARCH LIBRARY THESAURUS

Armidale Class Patrol Boat, Calm Water Resistance

19. ABSTRACT
DSTO has recently joined the International collaborative consortium FAST3.JIP with the aim to develop a numerical capability for the prediction and analysis of the resistance, seakeeping and seaway loads of high speed semi-planing hullforms. As part of this research program DSTO, in collaboration with DNPS, have undertaken a series of calm water resistance scaled model tests on the Armidale Class Patrol Boat, (ACPB). The data obtained from this model test program will be utilised to validate the numerical tools within the FAST3.JIP. Once fully validated these tools can be utilised to increase the understanding of any potential fuel saving strategies for the ACPB's and the through life structural management of the platform. The results will also be utilised to provide stern flap position advice to the Royal Australian Navy for minimisation of fuel consumption at various displacements and ship speeds. This report presents the data from the experimental test series.